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Investigating the adoption of indigenous knowledge in mitigating climate-linked challenges: a case study of Vhembe District in South Africa



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ABSTRACT

Indigenous knowledge (IK) plays a crucial role in rural African communities by contributing to the development of mitigation and adaptation strategies, enhancing resilience to climate-related challenges. However, there is limited documentation of its application in South Africa. This study investigates the adoption of IK in the Vhembe district, focusing on general use, disease prediction and farming practices. Results indicate that the respondents possessed a rich reservoir of IK, with 76.1% affirming its use for different purposes. Most respondents (75.3%) use IK for farming, with 63.1% using it for disease prediction. Most participants (74.3%) reported adequate confidence levels in their use of IK for general purposes. Respondents who had stayed longer in Vhembe reported higher confidence levels in using IK, as did those above 66 years old in using this knowledge system for disease prediction. The use of IK indicators for early warning of malaria outbreaks was also documented. Investigating and documenting IK use in communities could inform the basis for preservation and hence, enhance IK recognition. The integration of IK in the development of early warning systems may enhance their relevance and effectiveness in combating the effects of climate change and infectious diseases.

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Introduction

Indigenous knowledge (IK) encompasses informal, unique, traditional information, skills, and knowledge held by indigenous groups within specific regions (Grenier, 1998). This cumulative knowledge reflects wisdom gained through experiential learning, observations, and trial-and-error (Ahmad et al., 2016). IK is also dynamic, shaped by human innovation and interaction with external knowledge (Aswani et al., 2018). IK's is expressed through cultural practices, beliefs, values, laws, agriculture, and plant species (Grenier, 1998). The quantity and quality of IK vary based on factors like age, gender, roles, socio-economic status, curiosity, and experiences (Son et al., 2019).

Local communities use IK to develop mitigation and adaptation strategies to several challenges (Dube et al., 2018; Kom et al., 2022; Macherera et al., 2016; Nkengasong et al., 2020). These communities make observations and use environmental and astronomical indicators like the patterns and movement of clouds and objects in the night sky, the flowering or flushing of specific trees and plants, birds, insects, and animals' behaviour to understand their environment (Macherera et al., 2017, 2016; Membele et al., 2022; Son et al., 2019). For example, farmers in the Yao ethnic group in Vietnam use the shape and brightness of the moon to predict the weather for upcoming cropping season (Son et al., 2019). In Zimbabwe natural indicators are used to predict malaria outbreak (Macherera et al., 2017).

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Notwithstanding the many studies that have lauded the usefulness of IK to different communities, this ancient knowledge is not short of its critics (Grenier, 1998; Leal Filho et al., 2022). One major problem reported on IK is limited documentation (Kom et al., 2022). Additionally, Grenier (Grenier, 1998) called out IK for its incompleteness, and inaccuracy. Additionally, IK can only be used to make short seasonal forecast (Muthoni Masinde et al., 2018). Nevertheless, many researchers argue that IK is effective to a certain degree (Akanbi et al., 2018; Dube et al., 2018; Mbewe et al., 2019; Son et al., 2019).

Undocumented and underutilized IK in certain communities hampers its application in addressing challenges like climate change and infectious diseases (Dube et al., 2018; Jiri et al., 2016; Leal Filho et al., 2022). Leal Filho (Leal Filho et al., 2022) highlight the limited documentation of IK, particularly in African contexts, despite Africa being the continent most affected by climate change (Leal Filho et al., 2022). In South Africa (SA), despite a significant number of research studies on IK in SA, the focus has primarily been on education, ethnobotany, customs, traditions, agroforestry, and agriculture (Joseph Hlalele, 2019; Kgope, 2023; Lieketseng Yvonne Ned, 2019; Mhlongo, 2021; Ngunyulu et al., 2020). There is also notable limitation of research studies investigating IK for climate change adaptation in SA, like in other African countries (Leal Filho et al., 2022; Malapane et al., 2022).

In Vhembe District in Limpopo, SA, there is a dearth of documentation and exploration of IK's use for indigenous forecasting (Kom et al., 2022). Indigenous forecasting is crucial in farming practices and addressing climate change and infectious disease challenges in Vhembe (Dalu et al., 2022; Gwarinda et al., 2021; Louis et al., 2020). Vhembe district faces frequent natural disasters, including floods. In February 2019, Mangaya, Tshanzhe, and Maheni experienced severe floods (Dalu et al., 2022). Vhembe is prone to high incidences of infectious diseases. In 2018, the district had malaria incidence of 3.8 cases per 1000 person-years (Dieng et al., 2015). High incidences of malaria continue to be reported in Vhembe district (Gwarinda et al., 2021). Additionally, in Vhembe district, villages are predominantly occupied by small scale farmers who are more vulnerable to climate change (Kom et al., 2022). Regardless, there is limited research on IK in districts like Vhembe to address these challenges.

Thus, this study aims to achieve the following objectives:

- i. To investigate the integration of indigenous knowledge in mitigation and developing adaptation strategies to climate/weather and disease challenges in Vhembe district.
- ii. To determine the level of confidence of respondents in using indigenous knowledge for general purposes, disease prediction, and farming.
- iii. To investigate the indigenous knowledge indicators respondents, use for early warning of malaria outbreaks.

Research and Methodology

Data and Methods

Study area

This report presents a study conducted in Vhembe, a district in Limpopo province, South Africa. Vhembe consists of four municipalities: Musina, Makhado, Thulamela, and Collins Chabane (Figure 1).

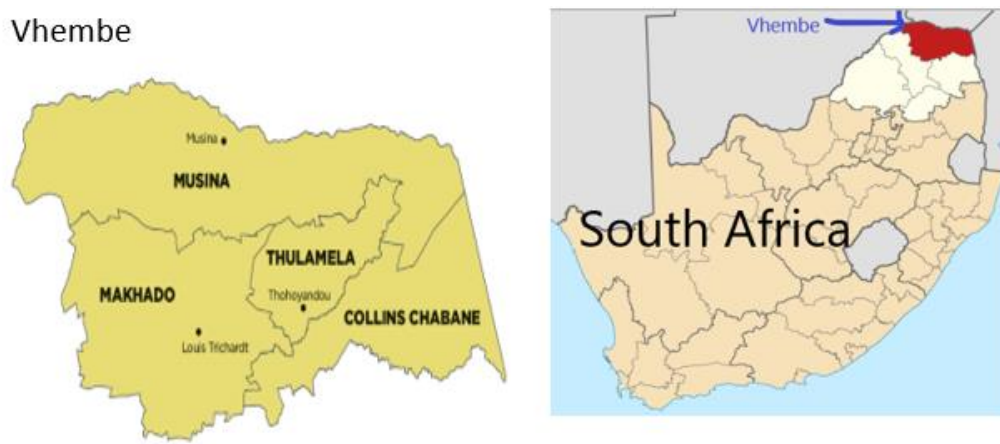


Figure 1: Vhembe district map

Vhembe spans 25,596km² with a population of 1,393,949. Vhembe has subtropical climate with moist winters and wet, warm summers. Rainfall averages 500mm annually, mostly in October to December. Winter temperatures reach 10 °C, while summer temperatures range from 34 °C–38 °C (Musetha, 2016). Agriculture is the primary occupation in rural communities (Kom et al., 2022).

Research design and sampling technique

The study adopted a quantitative approach with structured questionnaires (with one open ended question) administered to 155 respondents. The questionnaire had four sections: purpose and structure of the questionnaire, consent form, demographic information, and knowledge and use of weather information and IK. A multi-stage sampling technique was employed (Sharma, 2017). Purposive sampling selected respondents with IK in the first stage (Stratton, 2021), and the second stage used a snowball sampling technique based on referrals from existing respondents (Sharma, 2017). The questionnaire aimed at acquiring the following information from the respondents:

- i. Biodata of the respondents. Of importance from this data was the duration the respondents stayed in their villages, the main economic activities in the village and respondents’ age.
- ii. Knowledge on indigenous forecast to assess respondents’ use of IK and their confidence on the reliability of IK.

After data cleaning, 146 responses were considered. The collected data was analysed using the Statistics Package for Social Science (SPSS).

Results

Demographics of the Respondents

The respondents were selected from ten villages in Vhembe district, with the majority (51.1%) coming from Tshino, Tshivhulana, and Musina villages. Small-scale farming, business, and industry services were identified as the primary economic activities in the Vhembe. In terms of gender distribution, there were more males (67.12%) than females (32.88%). The respondents’ ages were recorded, with the highest representation in the age bracket of 65 years and above (37.67%). Almost a quarter (24.66%) of the participants aged 56–65 years, while those aged 18–25 years were the least represented (11.64%). Respondents under 18 were not represented due to the purposive sampling method, which aimed to include individuals with IK.

Migration history data was collected from the respondents, and it is shown in figure 2 according to age and gender. For instance, "5-10 years female" refers to female respondents who stayed in Vhembe for 5–10 years.

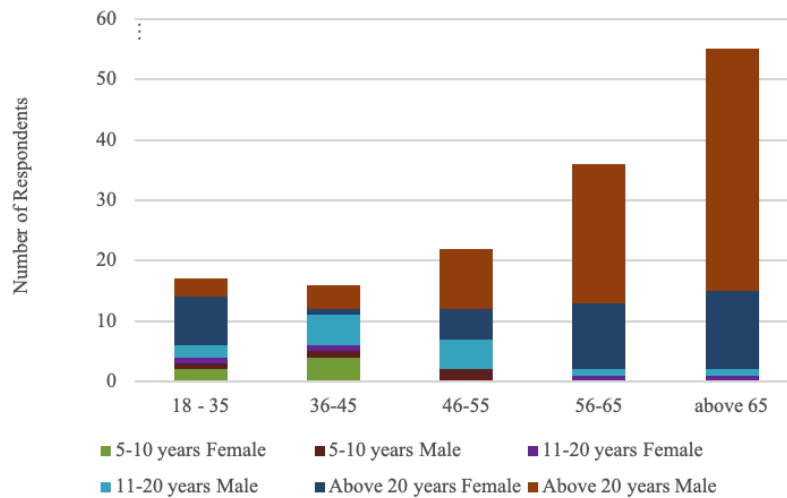


Figure 2: Respondents distribution by migration history, age, and gender.

The majority (80%) had been residing in their current village for over two decades. A smaller portion, 13.01% and 6.85%, had stayed for 11–20, and 5–10 years, respectively. This suggests that the sample comprised individuals with significant knowledge of the environment, including indigenous forecasting. Continuous and prolonged contact with the environment enhances observation and understanding of IK indicators (Grenier, 1998). It is also evident that the respondents who have stayed above 20 years in Vhembe are mostly males above 65 years old.

Respondents’ usage of weather forecast information.

The respondents were asked about weather forecast information in and the sources of this information. Options included radio, Television (TV), Internet, newspapers/print media, website/App, local observation (IK), and others for source of information. A significant proportion (95.65%) confirmed using weather information for more than five years, with 69.17% checking it daily, 26.32% weekly, and 2.26% monthly/seasonally. TV emerged as the primary source, followed by radio. Additionally, 105, 95, and 68 respondents utilized IK, website/App, and newspapers, respectively, for weather information. The respondents further rated the sources of the weather forecast information (Figure 3).

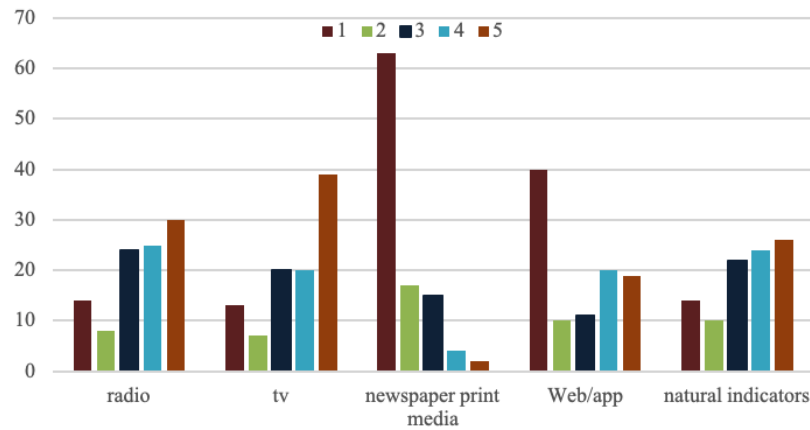


Figure 3: The rating of the sources of weather information

Respondents rated the adequacy of weather forecast information sources on a scale of 1 (lowest) to 5 (highest). For farming, traveling, and daily planning, TV, radio, and local indicators received high ratings, of 75%, 59%, and 70%, respectively, expressing confidence in them. Newspapers had the lowest rating. From the open-ended question, respondents who rated sources inadequately justified their ranking, citing reasons like inaccuracy, lack of specificity, and unclear communication to the community. Some respondents (48%) mentioned that changing climatic conditions and the disappearance of certain plants and animals might have diminished the reliability of IK indicators.

Respondents' usage on weather-related alerts

Respondents were asked to name weather-related alerts they receive and the communication channels they predominantly use. Alert options included heat stress, air quality, ultraviolet, malaria, and others. Communication channels consisted of radio, TV, Internet, newspapers/print media, website/App, local observation (IK), and others. The respondents indicated using weather-related alerts to guide activities like farming, travel, disease prediction, and daily planning (how to dress). Figure 4 reveals that most respondents (82.61%) received alerts, with the common ones being heat stress, thunderstorms, and wildfires (categorized as "others").

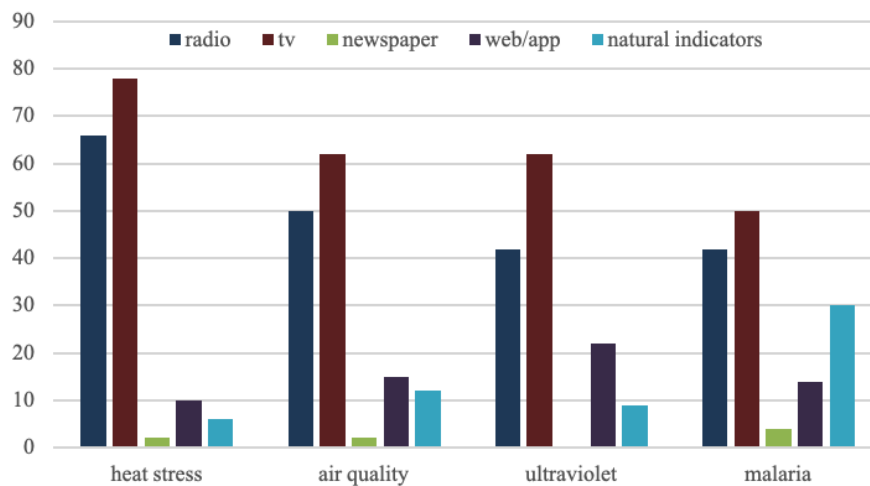


Figure 4: Weather-related alerts received in by respondents in Vhembe and the channels of communication.

Primary communication channels for acquiring these alerts were TV, radio followed by natural indicators. These communication channels were rated as the most accurate sources of weather-related alerts, as shown in figure 5. Newspapers received the lowest rating. The rating ranged from 1(lowest) to 5 (highest).

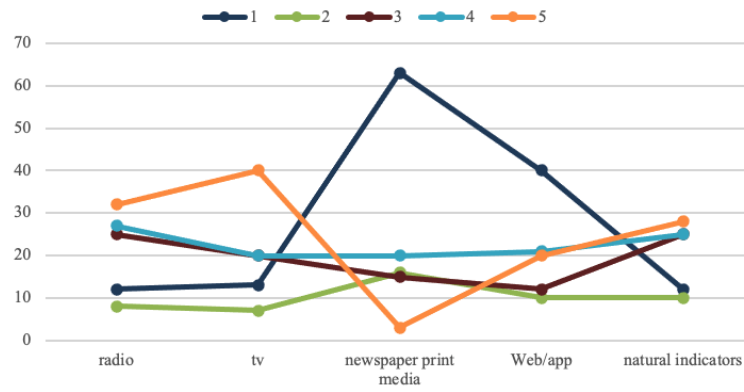


Figure 5: Level of the accuracy of the sources of weather-related alerts.

Level of confidence in the use of IK by Vhembe Community

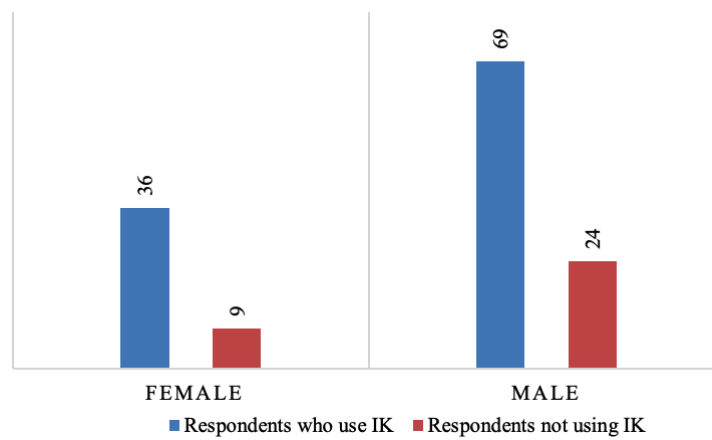


Figure 6: Use of IK by respondents

Most respondents (76.1%) reportedly used IK. Some Eight respondents did not answer the IK-related questions and were excluded from further analysis.

Level of confidence in general use of IK

This section analyses respondents' confidence level in the general use of IK based on gender, age, and migration history.

Use of IK by gender

Figure 7 illustrates the respondents' confidence levels, categorized by gender and age, regarding the general use of IK. Male respondents displayed higher confidence levels compared to females. Additionally, older individuals reported higher confidence levels in the use of IK than younger respondents.

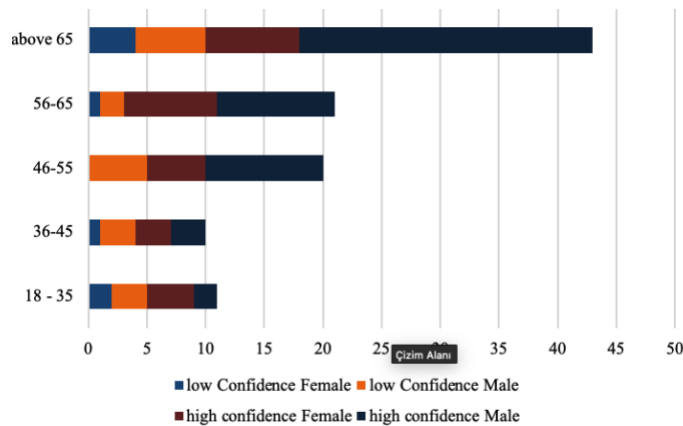


Figure 7: confidence in general use of IK by gender and age

To determine the significance of confidence levels, the Pearson chi-squared test was used. Contingency table (table 1) of the observed and expected data for confidence in general use of IK was constructed after collapsing the Likert scale (“very inadequate” and “inadequate” into one column and, “adequate” and “very adequate” into another column).

Table 1: Contingency table for confidence in general use of IK by gender

Gender	Inadequate Confidence	Adequate Confidence	Total
Female	8	28	36
Male	19	50	69
Total	27	78	105
Theoretical f/m ratio			0.52
Observed f/m ratio	0.42	0.56	

Most respondents (74.3%) expressed sufficient confidence level in the general use of IK. The theoretical and observed ratio between female and male users of IK was calculated to determine any association between respondents' gender and their confidence in general use of IK.

Table 1 illustrates the expected female/male (f/m) ratio of 0.52 in the original sample for the general use of IK. For respondents expressing adequate confidence level in IK's general use, the observed f/m ratio was 0.56 (>0.52). This indicates that proportionally more females reported higher levels of confidence in IK compared to males, with male counterparts showing a lower usage of IK (0.42 experimental ratio compared to 0.52 theoretical ratio). This association was verified through an inferential statistics procedure for any significant difference whereby the non-parametric Pearson chi-squared test was chosen at an alpha level of 0.05.

The following NULL hypothesis was formed:

There is insignificant difference between male and female respondents in their confidence in the use of IK.

From CHI-Squared results ($\chi^2(N=105 = 10.851, p = 0.744)$, with $P > 0.05$, we accept the null hypothesis. There is insignificant difference in general use of IK among the respondents according to gender, even though, figure 6 and table 2, suggested some association between gender of the respondents and their confidence in the use of IK in general.

Level of confidence in general use of IK according to age

Of interest also was the confidence of the respondents in the general use of IK by age. Table 2 indicates the confidence of the respondents by age.

Table 2: contingency table for the confidence in general IK use by age.

Age (years)	Inadequate Confidence	Adequate Confidence	Total
18-35	5	6	11
36-45	4	6	10
46-55	5	15	20
56-65	3	18	21
> 65	10	33	43
Total	27	78	105

Cramer’s V was used where the dependent variables had more than two levels (such as age). In such instances the Chi-squared would not be applicable (Field, 2013). Cramer’s V was used to examine the relationship between the level of confidence in the general use of IK and age. Cramer’s V ranges from 0 to 1, where 0 indicates no relationship and 1 indicates perfect association (Field, 2013). Cramer’s V test was run on the data to verify the association between age and confidence in the general use IK. The results of the confidence in general use of IK by age were as follows: $\chi^2(1) = 12.20, p = 0.005$, Cramer's V = 0.01, odds ratio = 1.49 [95% confidence interval = 1,27, 1.74]. The interpretation of Cramer’s V results was guided by table 3 (Akoglu, 2018).

Table 3: Cramer's V and interpretation

Cramer’s V	Interpretation
> 0.25	Very strong
> 0.15	Strong
> 0.10	Moderate
> 0.05	weak
>0	No/very weak association

The results (Cramer’s V at 0.01) suggest very weak to no association in the use of IK among the respondents according to age regardless of the observations made in figure 7.

Level of confidence in general use of IK by migration history

Table 4 below indicates the respondents’ level of confidence in the general use of IK by migration history. Respondents who stayed longer in Vhembe reported higher levels of confidence in the general use of IK.

Table 4: Contingent table for the general use of IK by migration history

Years	Inadequate Confidence	Adequate Confidence	Total
5-10	3	5	8
11-20	5	9	14
>20	19	64	83
Total	27	78	105

Cramer’s V analyses were run to verify the association between migration history and confidence in general use of IK. The following results were obtained: ($\chi^2(1) = 12.20, p = .005$, Cramer's V = 0.28, odds ratio = 1.49 [95% confidence interval = 1.27, 1.74]). Cramer’s V at 0.28, indicates a very strong association in use of IK among the respondents according to migration history.

Level of confidence in IK use for disease prediction

Confidence in IK for disease prediction by gender

Of 105 respondents that reportedly used IK, 87 (82.9%) indicated that they used IK for disease prediction. These respondents constitute 63.1% of the original sample, (138). Figure 8 depicts the distribution of the use of IK for disease prediction by age and gender.

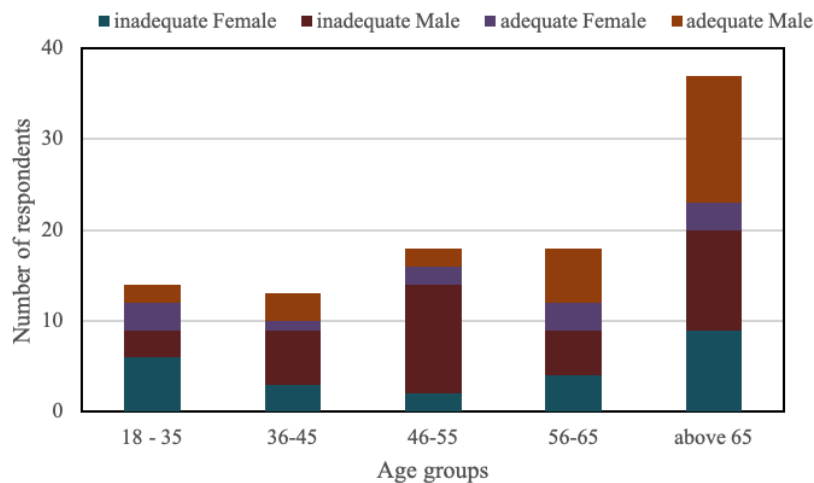


Figure 8: Confidence in IK use for disease prediction by gender and age.

Table 5 shows that 57.5% of the respondents expressed adequate confidence levels in the use of IK for disease prediction. Table 5 suggests that males aged 66 and above exhibited greater confidence in using IK for disease prediction. Male respondents demonstrated higher levels of confidence in using IK for disease prediction compared to their female counterparts.

Table 5: Contingent table for confidence in IK use for disease prediction by gender.

Gender	Adequate Confidence	Inadequate Confidence	Total
Male	32	24	56
Female	18	13	31
Total	50	37	87
Theoretical m/f ratio			1.81
Observed m/f ratio	1.78	1.85	

From table 5, the expected ratio is 1.81 considering the male/female sample ratio in original sample. For those who felt inadequately confident the ratio is 1.78 (< than 1.81). Proportionally, females reported lower confidence levels. Their male counterparts reported

higher confidence levels (1.85 experimental ratio compared to 1.81 theoretical ratio). The association was verified for significance using Chi-squared test, at an alpha level of 0.05 and the following null hypothesis was formed:

There is insignificant difference between male and female respondents in their confidence in the use of IK in disease prediction.

CHI-Squared results were as follows: $\chi^2(N=87) = 10.851$, $p = 0.744$. Therefore, the Null hypothesis is accepted. The results suggest insignificant difference in use of IK for disease prediction among the respondents according to gender regardless of the observation made from table 5.

Level of confidence in IK use for disease prediction by age

Association between the age and confidence levels of respondents in their use of IK for disease prediction were also investigated. The contingent table below (table 6) shows confidence levels of the respondents in IK use for disease prediction by age.

Table 6: contingency table of confidence in IK use for disease prediction by age

Age(years)	Inadequate Confidence	Adequate Confidence	Total
18-35	6	5	11
36-45	7	3	10
46-55	14	4	18
56-65	5	8	13
>65	18	17	35
Total	50	37	87

Cramer’s V was run to verify the association between age and Confidence in IK use for disease prediction.

Null hypothesis: There is insignificant association between age of respondents and their confidence in IK use for disease prediction.

The following results were obtained: $\chi^2(1) = 12.20$, $p = .005$, Cramer’s V = 0.16, odds ratio = 1.49 [95% confidence interval = 1,27, 1.74]. With Cramer’s V at 0.16, we conclude that there is a strong association in use of IK among the respondents according to age. Respondents above 66 years old, have more confidence in the use of IK for disease prediction as compared to younger respondents.

Confidence in the IK use for prediction of disease by migration history

The contingency table below illustrates the confidence levels of respondents in using IK for disease prediction based on migration history.

Table 7: Contingent table for the confidence in the use of IK for disease prediction by migration history.

Years	Inadequate Confidence	Adequate Confidence	Total
5-10	5	3	8
11-20	10	3	13
> 20	35	31	66
Total	50	37	87

The association between migration history and confidence in using IK for disease prediction was determined for significance using Cramer’s. Null hypothesis was as follows: There is insignificant association between migration history of respondents and their confidence in IK use for disease prediction. These results were obtained: $\chi^2(1) = 12.20$, $p = .005$, Cramer’s V = 0.29, odds ratio = 1.49 [95% confidence interval = 1,27, 1.74]. Cramer’s V at 0.29, suggests a very strong association in the use of IK for disease prediction among the respondents according to migration history. Respondents who had lived in Vhembe for over 20 years reported higher confidence level compared to those with shorter residency.

Level of confidence in Use of IK for farming

The results suggest that respondents used IK for farming more than for disease prediction. Out of the total sample, 104 respondents (75.3%) and 87 respondents reported using IK for farming, and disease prediction, respectively. Most respondents (82.3%) expressed adequate confidence in the use of IK for farming.

Similar procedures (as in previous sections) were used to determine the confidence levels of respondents in the use of IK for farming by gender, age, and migration history. When it comes to the confidence respondents have in the use of IK for farming by gender (X2 (N=104) = 3.849, $p = 0.94$, $P > 0.05$) and age (Cramer’s V = 0.02). The results suggest insignificance association or no association between the age or gender and IK use for farming. Different results were obtained for the confidence in IK use for farming according to migration history Based on results obtained: ($\chi^2(1) = 12.20$, $p = .005$, Cramer’s V = 0.32, odds ratio = 1.49 [95% confidence

interval = 1,27, 1.74]), there is a very strong association in use of IK for farming among the respondents according to migration history.

Table 9 summarizes the analysis results for the respondents' level of confidence in the general use of IK and the use of IK for disease prediction and farming based on age, gender, and migration history.

Table 9: A summary of the level of the confidence respondents in IK use with respect to gender, age, and migration history.

	Confidence in general use of IK	Confidence in use of IK for	
		disease prediction	farming
gender	Insignificant association	Insignificant association	Insignificant association
age	Insignificant association	Significant association (Cramer's V = 0.16)	Insignificant association
migration history	Significant association (Cramer's V = 0.28)	Significant association (Cramer's V = 0.29)	Significant association (Cramer's V = 0.32)

The Indigenous Knowledge indicators for malaria prediction

The study investigated IK indicators for malaria prediction by participants. Table 10 shows the IK indicators for malaria prediction grouped into seven categories, and by seasons.

Most IK indicators for malaria outbreak are observed during spring and summer. These indicators primarily consist of astronomical and meteorological observations. Only a few indicators were based on myths, religious beliefs, or other factors.

Discussion

The results suggest that Vhembe district communities possess rich IK and have continued to use it for various forecasting purposes that include informing farming decisions, disease prediction and planning daily activities. Generally, participants showed high confidence levels in the use of IK for farming compared to other activities. The use of IK for farming in Vhembe has also been reported by (Kom et al., 2022). Kom et al., (2022) indicated that some communities in Vhembe still rely on IK for farming decisions. The notable use of IK for farming may attribute to the fact that farming is the main economic activity in Vhembe. Even though Vhembe community has rich IK, there is a scarcity of research projects that document or/and explore the use of IK in Vhembe. There is substantial literature on the use and exploration of IK in other regions (Macherera et al., 2016; Son et al., 2019). For an example, (Membele et al., 2022) used IK to map flood vulnerability in informal settlement. Furthermore, several researchers have already integrated IK and modern science to solve complex problems that neither modern science nor IK alone could solve (Akanbi et al., 2018; M Masinde, 2015). For instance, Masinde integrated IK with artificial intelligence to predict drought in Kenya (M Masinde, 2015).

The participants from Vhembe communities expressed adequate level of confidence in IK especially for farming (82%), with confidence levels for general purposes and disease predictions reporting 74.3% and 52.5% in general purposes and disease prediction respectively. The findings suggest very strong association in use of IK among the respondents according to migration history. The respondents who had resided more than 20 years in Vhembe tended to have high usage of IK and have high confidence levels in its use. Respondents who resided for at least 20 years in Vhembe showed more confidence in the use of IK for general purposes and disease prediction, than those who had resided for a shorter period. These results could be explained by the fact that IK is acquired through a prolonged interaction time with the environment by a group of people indigenous to a particular geographic area (Grenier, 1998).

The findings further suggest that knowledge base and confidence of respondents in IK is being weakened by factors such as climate change. This point synchronises with the concern raised by respondents in the study by (Kom et al., 2022). A lack of proper knowledge transfer, documentation, dissemination, influence of religion and education, lack of recognition of forecasters, and environmental degradation and extinction of biological indicators, economic, can also impoverish IK system especially if IK systems are not being supported (Aswani et al., 2018). In SA, factors such as limited legislation and policy frameworks for IK system, and scarcity of research projects to support the use of IK also pose a threat to the loss of IK (Kom et al., 2022). Several researchers contest that IK, if not ignored, would continue to play a significant role for local communities and the authorities (Akanbi et al., 2018; Aswani et al., 2018; Dube et al., 2018).

The results also suggests that Vhembe communities also possess rich IK on malaria outbreak indicators. The indicators include astronomical and meteorological observations, with only a few indicators based on myths and religious beliefs. Natural indicators have been used for early warning of malaria in other regions such as Zimbabwe (Macherera et al., 2017). In Vhembe, natural indicators were used to inform farming decisions under climate change. Indeed, IK has a potential of mitigating the impacts of climate change in Limpopo (Kom et al., 2022).

Conclusions

This study investigated the use of IK in Vhembe, a South African District. The research focused on the application of IK for general use, farming activities, and in predicting infectious diseases. The study also investigated the levels of confidence the participants felt in their use of IK in the various domains. The findings of the study suggest that there is a rich IK reservoir in the Vhembe community. A high number of participants (76.1%) reported using IK for general purposes, with 75.3% reportedly using IK for farming activities, and 63.1% using it for disease prediction. Participants also reported high confidence levels in their use of IK for various purposes. Respondents who had lived in Vhembe District for at least 20 years reported higher confidence levels in their use of IK. Older respondents also reported higher confidence levels in their use of IK for disease prediction as compared to younger participants. The findings of this study compliment previous studies in confirming IK as a critically valuable resource in the rural African communities such as Vhembe. Continued research on IK use in such communities could assist in preserving this knowledge system and may further enhance its recognition. Furthermore, the development of IK-based early warning systems may also be explored to combat the adverse effects of climate change and infectious diseases. Future studies could focus on blending IK systems with modern science. Integrating both IK and modern knowledge takes advantages of their respective strengths to build even more robust knowledge systems that can assist in mitigating the increased adverse impact of climate change worldwide, especially in poor communities. This research study recommends that local municipal authorities, and policy makers should work in concert to enhance the preservation of IK systems in communities.

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All authors have read and agreed to the published version of the manuscript.

Author Contributions: Conceptualization, P.P., and M.M.; methodology, P.P. validation, M.M.; formal analysis, P.P.; investigation, P.P., and M.M.; resources, M.M.; writing—original draft preparation, P.P.; writing—review and editing, P.P. and M.M.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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